Chapter 15

Complications of thoracic aortic endografts: Spinal cord ischemia and stroke

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INTRODUCTION

Up until the last 5 to 10 years, patients with aneurysms of the thoracic and thoracoabdominal aorta had only one treatment option: open surgical repair. For those patients who could not tolerate operation because of medical comorbidities, continued aneurysm enlargement and eventual rupture was a constant—yet unpredictable—threat to their lives. Several studies have documented improved survival rates in those patients treated surgically.[1,2]

Despite advances in surgical reconstruction and organ protection, the mortality rate for elective repair of thoracoabdominal aortic aneurysms ranges from 4% to 21%; advanced age, renal failure, and postoperative paraplegia are the most important risk factors predicting mortality at 30 days. In addition, for those patients age ≥79 with an emergency presentation, history of diabetes mellitus, or congestive heart failure, 30-day mortality is 50%. For aneurysms isolated to the descending thoracic aorta, the risk of paraplegia is 0% to 4% and appears to be dependent on the extent of aorta replaced.[3] A substantial number of patients surviving the operation have prolonged, complicated courses secondary to renal, cardiac, and pulmonary dysfunction. Perhaps the most devastating complication of these complex procedures (for patients and their surgeons) is paraplegia.[4]

A myriad of techniques have been developed to protect the spinal cord during open surgical repair of the thoracic and thoracoabdominal aorta, including "clamp and sew," distal aortic and visceral perfusion, complete cardiopulmonary bypass, profound hypothermia and circulatory arrest, direct spinal cord cooling, cerebrospinal fluid (CSF) drainage, and pharmacologic adjuncts; some of these principles may be useful in preventing paraplegia at the time of endovascular repair. When the thoracic aorta is cross-clamped, spinal perfusion pressure decreases while CSF pressure increases, resulting in decreased perfusion pressure.

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In an important study of 1004 patients by Safi et al,[5] the incidence of immediate postoperative neurologic deficit occurred in 6.8% of patients who were operated on without the adjuncts of CSF drainage and distal aortic perfusion, whereas only 2.4% of those operated on with adjuncts had this devastating complication. These authors also stressed the importance of reimplantation of intercostal arteries, especially in the vulnerable area between T9 and T12, which frequently gives rise to the anterior spinal artery. Relative hypertension in the immediate postoperative period (maintaining mean arterial pressure between 90 and 100 mm Hg) is also advocated. Other risk factors for paraplegia in their series included extent of aneurysmal disease, advanced age, emergency presentation, preoperative renal dysfunction, active smoking, and cerebrovascular disease. Additionally, delayed paraplegia has been noted as late as 2 weeks after surgery and has been successfully treated by placement of a spinal drain.[6]

PARAPLEGIA AND PARAPARESIS

Substantial controversy exists with respect to elective repair of abdominal aortic aneurysms with endografts in good-risk patients owing to the excellent perioperative mortality and long-term durability of open surgical repair.[7] The promise of endovascular repair of thoracic aortic aneurysms, however, is that of decreased perioperative mortality and morbidity (especially with respect to paraplegia, permanent renal failure and stoke) in a population of patients who heretofore did not have an alternative to open surgical therapy or expectant treatment. Although there is a paucity of well-controlled data upon which to base definitive statements and clinical practice, a review of case series within the available literature allows for some general assumptions to be made.

In one of the first reported series by Dake et al[8] in 1994, 13 patients were treated with homemade endovascular stent-grafts over a 24-month period. All of the grafts were successfully deployed, and no patients died or had stroke, paraplegia or distal embolization. These results generated incredible enthusiasm for this novel procedure.

Subsequent reports in larger groups of patients were, however, more sobering. The EUROSTAR and United Kingdom registries, reported in 2004 by Leurs et al,[9] examined 443 patients who had undergone endovascular repair of a variety of pathologies involving the thoracic aorta, including degenerative aneurysms, aortic dissections, anastomotic aneurysms, and traumatic ruptures. In the entire cohort, 11 instances of paraplegia or paresis occurred, for an incidence of 2.5%. Most of the patients with this particular complication (10 of 11) were in the group that had an atherosclerotic aneurysm. One patient in the aortic dissection group and no patients in the false aneurysm and traumatic rupture groups were affected. Understandably, given the heterogeneous nature of the patient population and practice variability across the 62 participating centers, there are no reported data on the use of spinal drains.

Chiesa et al[10] reported on 103 patients treated electively for thoracic aortic lesions, 88 (85%) of which were atherosclerotic aneurysms. Preoperative CSF drainage was used in seven patients (based on data extrapolated from their experience with open surgical repair), including those with aneurysms involving critical intercostal arteries (T8 to T12), those requiring coverage of a long segment of the thoracic aorta (>20 cm), and in patients with prior repair of an abdominal aortic aneurysm. Four patients (4%) had delayed neurologic deficit that completely resolved after the institution of CSF drainage, systemic steroid therapy, and pharmacologic support of blood pressure. Univariate analysis identified only a perioperative mean arterial blood pressure of <70 mm Hg as a significant predictor of spinal cord ischemia ($P < .0001$).

Greenberg et al[11] from The Cleveland Clinic prospectively evaluated their results in 100 patients treated with investigational Zenith (Cook, Bloomington, Ind) devices. Of note, a spinal drain was placed preoperatively in 84% of their patients. Acute spinal cord ischemia was noted in 7.4% of 81 patients treated for atherosclerotic aneurysms, although only two of these six patients had a permanent deficit. Paraplegia or paraparesis did not develop in any patients treated for chronic dissection with aneurysm or other indications.

Finally, Makaroun et al[12] have reported results from a multicenter trial of the Gore TAG thoracic endograft (W. L. Gore & Associates, Flagstaff, Ariz), the only device currently available outside of US Food and Drug Administration-approved clinical trials. The device was successfully implanted in 139 patients, and spinal drains were not routinely placed before the procedures. Either temporary or permanent spinal cord deficit developed in four patients (3%). One patient was found to have paraplegia immediately following the procedure that did not resolve after placement of a spinal drain. Symptoms developed in a second patient 6 hours after surgery, associated with an episode of hypotension. Symptoms improved (but did not abate entirely) after stabilization of blood pressure and placement of a spinal drain. In the third and fourth patients, symptoms developed on the first postoperative day; both were ambulating at the time of their discharge.

Complications of thoracic aortic endografting, compiled from case series in the peer-reviewed literature (and having at least 20 cases), are listed in Table I. Thirty-day mortality is 0% to 19%, with a weighted average of 6.7% in this complex patient group. Likewise, there is a broad range in the incidence of spinal cord ischemia, from 0% to 12.5%, with an average of 2.7% in 1895 patients. The use of spinal drains in these citations is quite variable; some centers use them selectively in high-risk anatomic situations, whereas others use spinal drains only after patients become symptomatic. The use of this important adjunct must be individualized, and must also be based on its safety and ease of use at each institution. Indications for placing a spinal drain, based on our current practice, are listed in Table II. The drain remains in place for 24 hours in an intensive care unit setting and is then removed. While in place, it is allowed to drain to maintain a CSF pressure of 10 mm Hg.

Table I. Complications of endovascular treatment of thoracic aortic pathology

Author/year	*N*	*30-day mortality (%)*	*Stroke*	*Paraplegia/ paraparesis (%)*
Mitchell, 1999	103	9 (9)	7 (7)	3 (3)
Won, 2001	23	0	0	0
Taylor, 2001	37	3 (8)	1 (2.7)	0
White, 2001	26	1 (4)	0	1 (4)
Gravereaux, 2001	53	0	0	3 (5.6)
Cambria, 2002	28	1 (3.5)	0	0
Thompson, 2002	46	2 (4.3)	0	0
Criado, 2002	47	1 (2.1)*	0	0
Lepore, 2002	43	3 (7)	8 (18.6)	3 (6.9)
Usui, 2002	24	0	1 (4.2)	3 (12.5)
Ellozy, 2003	84	5 (6)	0	3 (3.6)
Bell, 2003	67	5 (7.4)	3 (4.5)	3 (4.5)
Chabbert, 2003	47	4 (8.5)	0	0
Krohg-Sorensen, 2003	20	2 (10)	0	0
Lambrechts, 2003	26	0	0	0
Schoder, 2003	28	0	0	0
Matravers, 2003	24	2 (7)	0	0
Lamme, 2003	21	0	0	0
Orend, 2003	74	7 (9.5)	0	2 (2.7)
Neuhauser, 2004	31	6 (19)	1 (3)	2 (6)
Bortone, 2004	132	4 (4)	0	0
Brandt, 2004	22	1 (4.5)	1 (4.5)	1 (4.5)
Leurs, 2004	443	41 (9)	10 (2.3)	11 (2.5)
Hansen, 2004	59	10 (16.9)	2 (3.4)	1 (1.7)
Makaroun, 2005	139	2 (1.5)	5 (4)	4 (3)
Chiesa, 2005	103	1 (1)	1 (1)	4 (4)
Greenberg, 2005	100	17 (17)	2 (2)	6 (6)
Melissano, 2005	45	0	0	1 (2)
Total	1895	127 (6.7)	42 (2.2)	51 (2.7)

*An additional patient died, after 30 days, of aortic rupture.

Table II. Indications for the use of cerebrospinal drains in patients requiring thoracic endografts

1. Anticipated endograft coverage T9-T12 (location of anterior spinal artery)
2. Coverage of long segment of thoracic aorta
3. Compromised collateral pathways (eg, previous infrarenal aortic aneurysm repair)
4. Symptomatic spinal ischemia (in a patient who did not have a drain placed preoperatively)

STROKE

The incidence of stroke, like spinal cord ischemia, also varies widely (Table I) and is likely multifactorial in etiology. In the Gore TAG trial, five patients (3.5%) had this complication, one of which was fatal; the remaining four were disabled enough to require rehabilitation after hospital discharge. Of interest, four of the five patients had left carotid-subclavian bypass either as a staged intervention or part of the endograft procedure. All four had proximal aneurysmal disease that required coverage of the left subclavian to achieve adequate proximal fixation. Three of the five strokes involved both the anterior and posterior circulation. Of 28 patients having carotid-subclavian intervention, four had strokes (14%), compared with 1% of patients who did not require this adjunctive operation.

The location of these strokes and their association with proximal aneurysmal disease implicates multiple emboli (to the anterior and posterior circulation) arising from the aortic arch, likely from catheter, guidewire, or endoprosthesis manipulation in a diseased arch. Other potential etiologies for stroke include air embolus, cervical carotid disease, and vertebral-basilar disease (especially when the left subclavian/vertebral is covered by the endograft and not revascularized).

Our policy has been to evaluate the aortic arch with transesophageal echocardiography in an attempt to identify a "shaggy" arch or free-floating thrombus that may preclude safe endograft placement. Planned endograft coverage of the left subclavian artery demands preoperative confirmation of right vertebral patency; in addition, computed tomography angiography or contrast angiography of the aortic arch will identify the occasional patient in whom the left vertebral arises as a separate branch from the arch. Also see Chapter 12 on subclavian artery transposition and Chapter 13 on total aortic arch debranching.

OTHER COMPLICATIONS

A myriad of other complications have been described following placement of thoracic endografts, including fatal access failure (iliac artery rupture), device migration, retrograde dissection, and aortoesophageal fistula.[12-15] Postimplant syndrome has been described after endovascular repair of abdominal aortic aneurysms and includes fever, pain, leukocytosis, and elevation of systemic inflammatory markers. Several reports have noted a similar scenario after endovascular repair of thoracic aortic aneurysms. Schoder et al[16] described fever (36%), leukocytosis (37%), pleural effusion (50%), periaortic atelectasis (41%), and elevated C-reactive protein (92%) in a series of 28 consecutive patients. In another report by Won et al,[17] nearly half (10/23, 43%) of their patients had a similar postoperative course. When associated with back pain, the suspicion of aortic leak arises, typically necessitating urgent aortic imaging, which invariably finds the endograft and the aorta to remain intact; treatment includes anti-inflammatory agents, antibiotics, and patient reassurance.

CONCLUSION

The mechanisms of spinal cord ischemia and stroke following endovascular treatment of thoracic aortic pathology are likely multifactorial and remain poorly defined. A thorough knowledge of the etiology of these complications following open surgical repair of thoracic and thoracoabdominal aortic aneurysms is essential in our attempt to prevent them after endovascular repair. Particular attention to anatomic factors that may place patients at increased risk, such as aneurysm extent, compromise of collateral pathways to the anterior spinal artery, and the presence of aortic arch disease, may allow for modifications in technique to decrease their incidence.

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